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H4M MN

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WO 98/43376 A WO 98/34362 A

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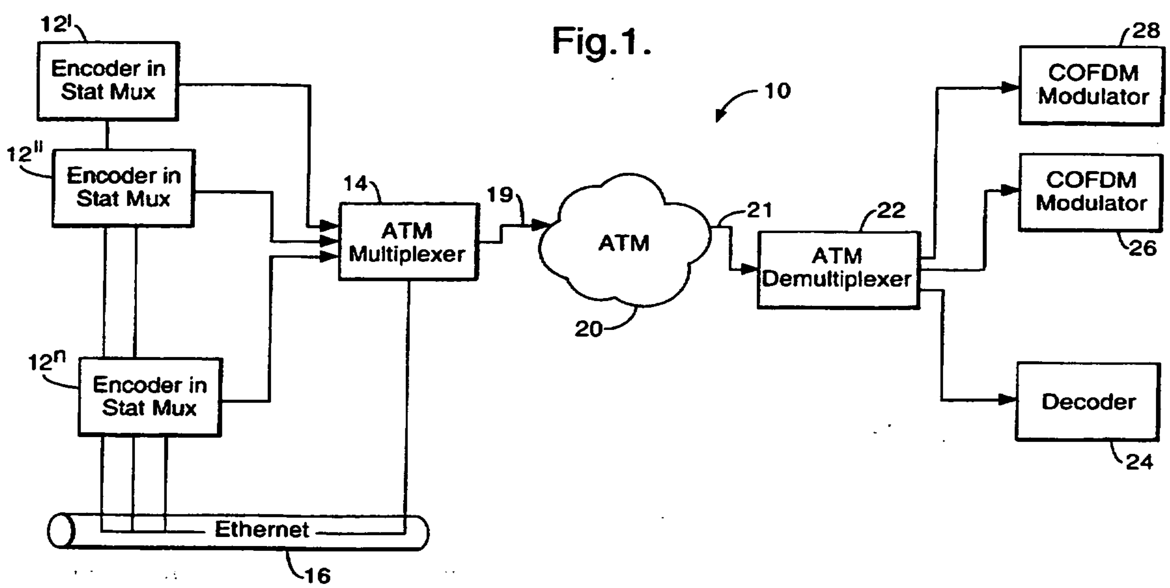
ONLINE : WPI ; EPODOC ; JAPIO

(54) Abstract Title
Statistical multiplexing

(57) A statistical multiplexing method for combining one or more digital signals into a data stream and transmitting said data stream as a variable bitrate data stream. One method comprising the steps of: producing an artificial constant bitrate data stream from a combination of the or each digital signal and null material; and removing the null material from the constant bitrate data stream to produce the variable bitrate data stream.

This has the advantage that a VBR implementation for Statistical Multiplexing is provided using an ATM network, which implementation does not contravene the requirements of the MPEG 2 Standard. Since the transmission can occur at a VBR the bandwidth needed for transmission can be significantly reduced when compared to the CBR scheme. This has consequential cost savings for transmissions of specific numbers of signals.

Fig.1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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Fig.1.

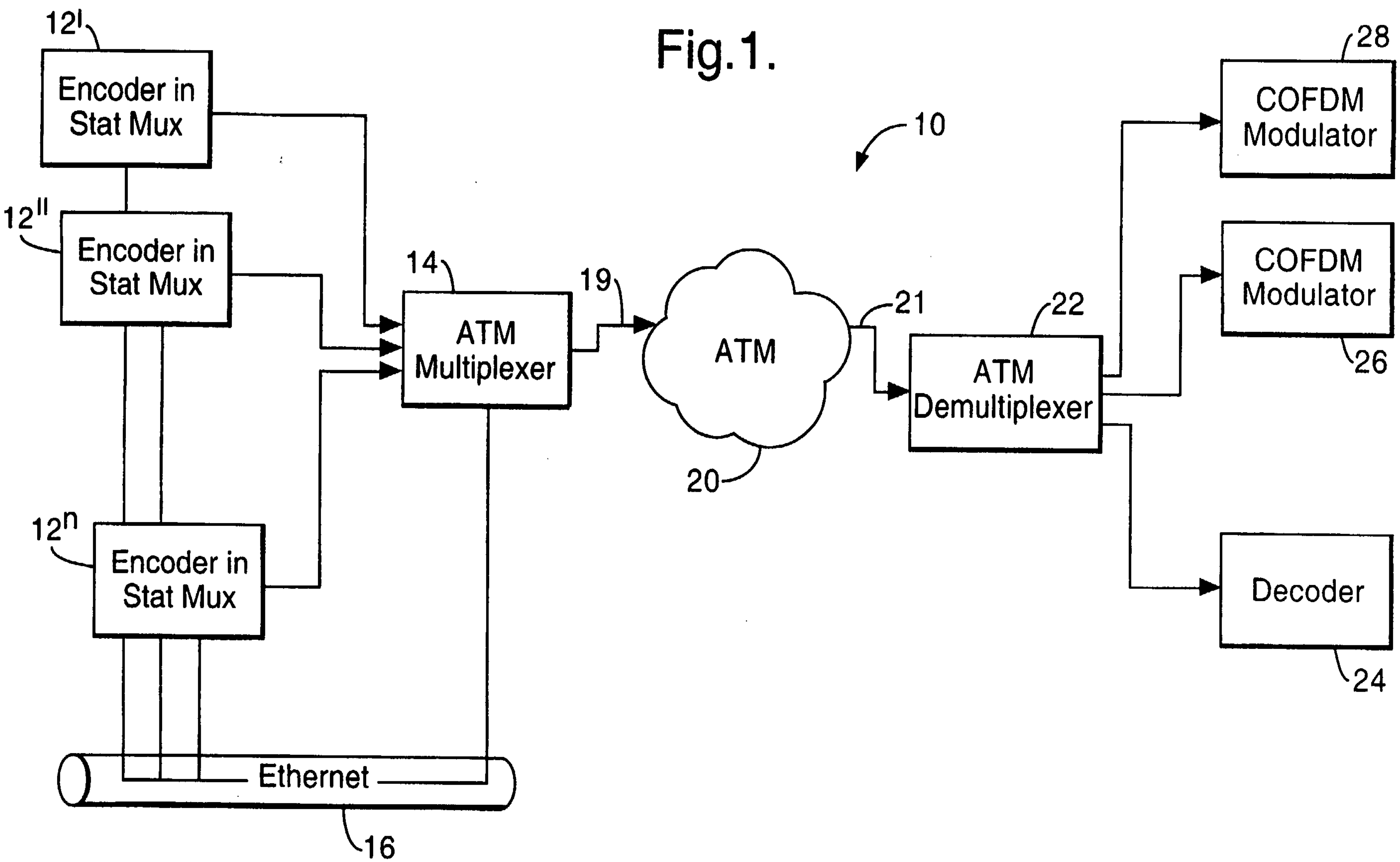
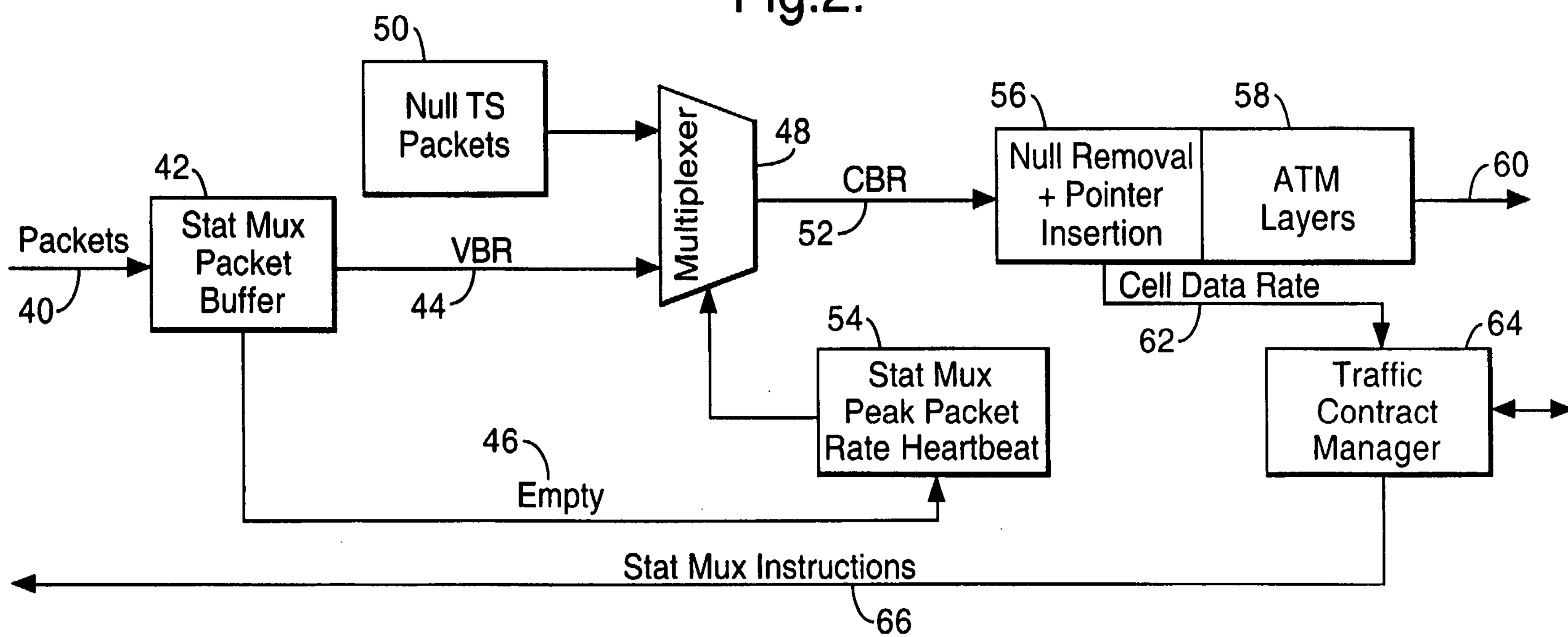

10
12I
Encoder in Stat Mux
12II
Encoder in Stat Mux
12n
Encoder in Stat Mux
14
ATM Multiplexer
Ethernet
16
19
ATM
20
21
22
ATM Demultiplexer
28
COFDM Modulator
26
COFDM Modulator
24
Decoder

Fig.2.



Packets
40
Stat Mux
Packet
Buffer
42
Null TS
Packets
50
VBR
44
Multiplexer
48
CBR
52
Null Removal
+ Pointer
Insertion
56
ATM
Layers
58
60
Cell Data Rate
62
Stat Mux
Peak Packet
Rate Heartbeat
54
46
Empty
Traffic
Contract
Manager
64
Stat Mux Instructions
66

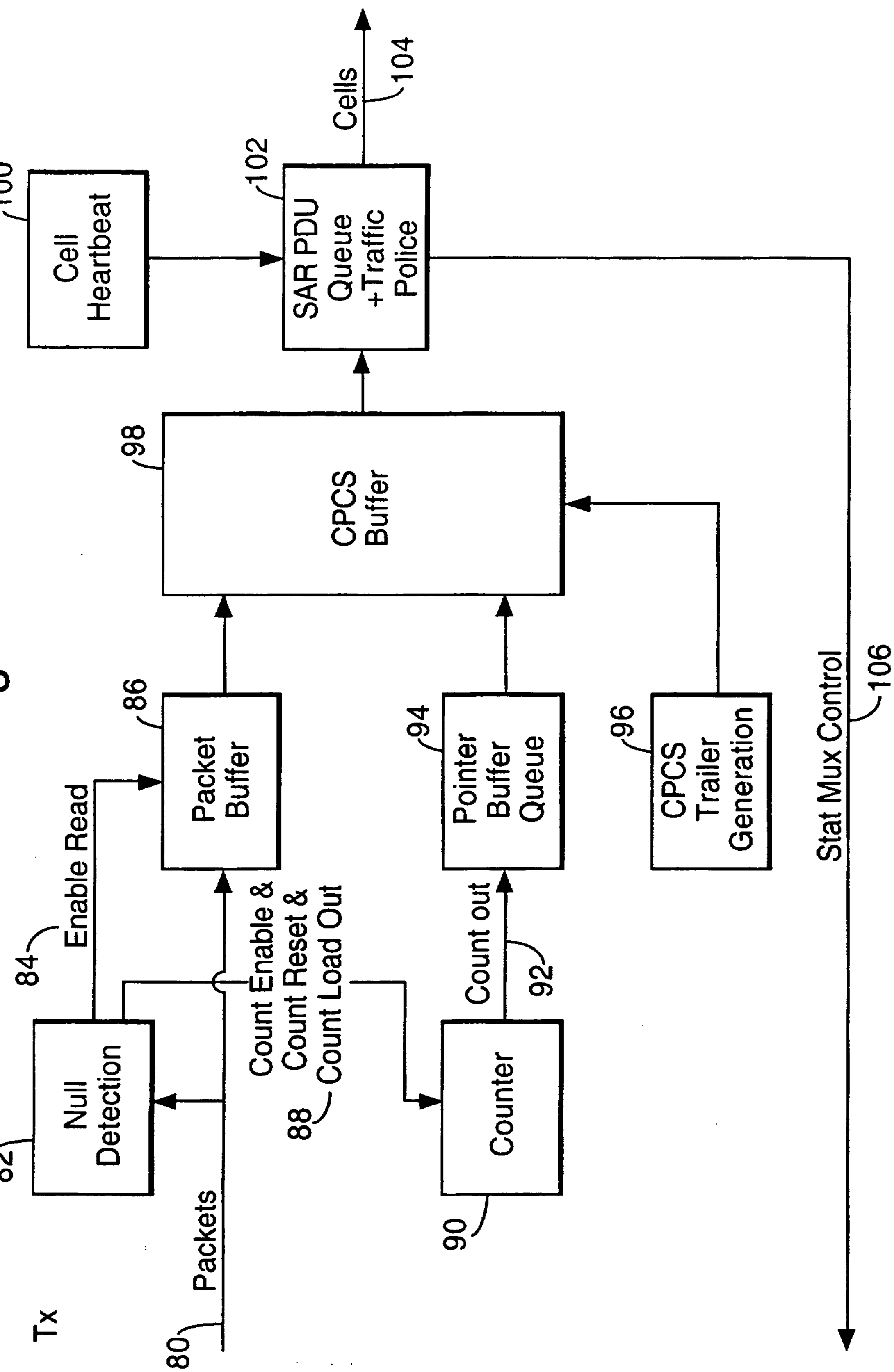
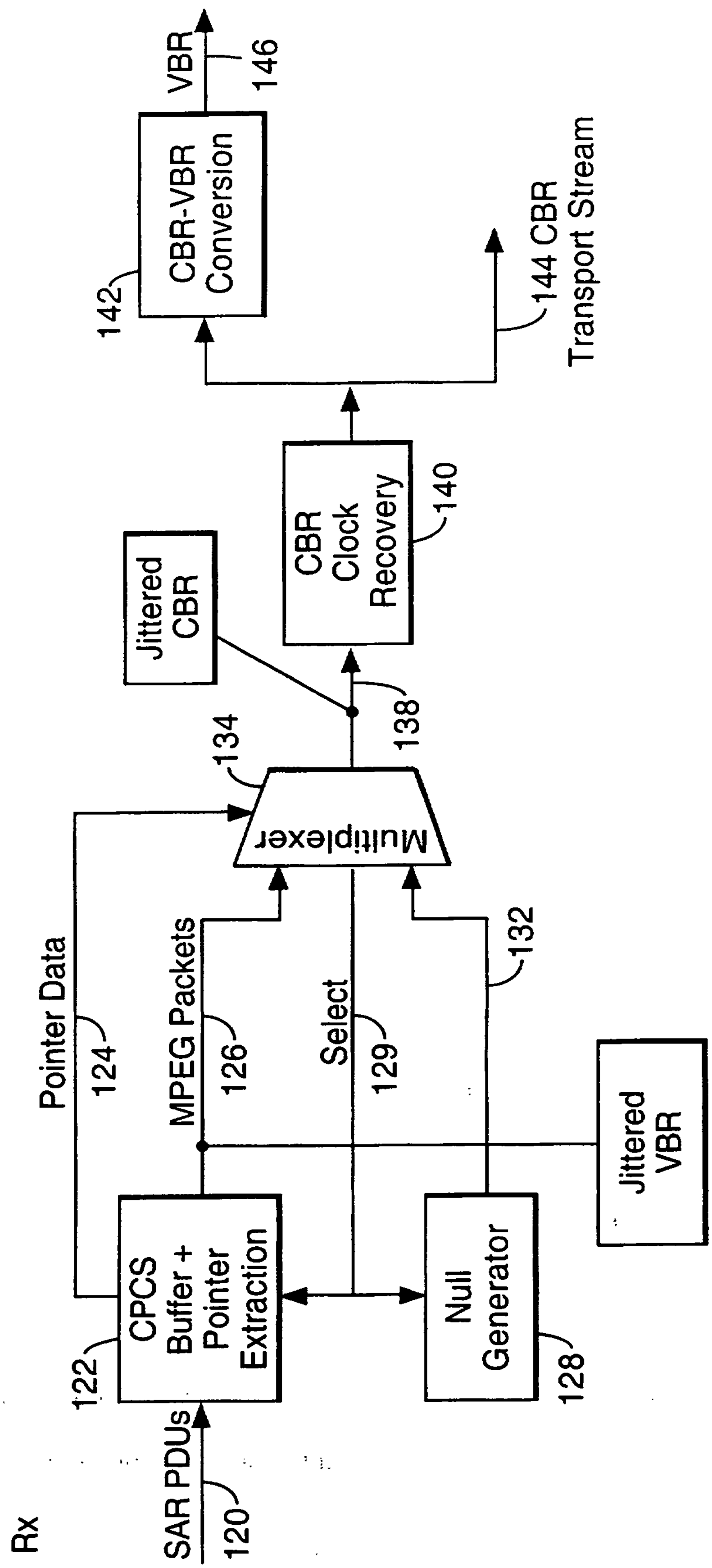

Tx
80
Packets
82
Null Detection
84
Enable Read
86
Packet Buffer
88
Count Enable & Count Reset & Count Load Out
90
Counter
92
Count out
94
Pointer Buffer Queue
96
CPCS Trailer Generation
98
CPCS Buffer
100
Cell Heartbeat
102
SAR PDU Queue +Traffic Police
Cells
104
Stat Mux Control
106

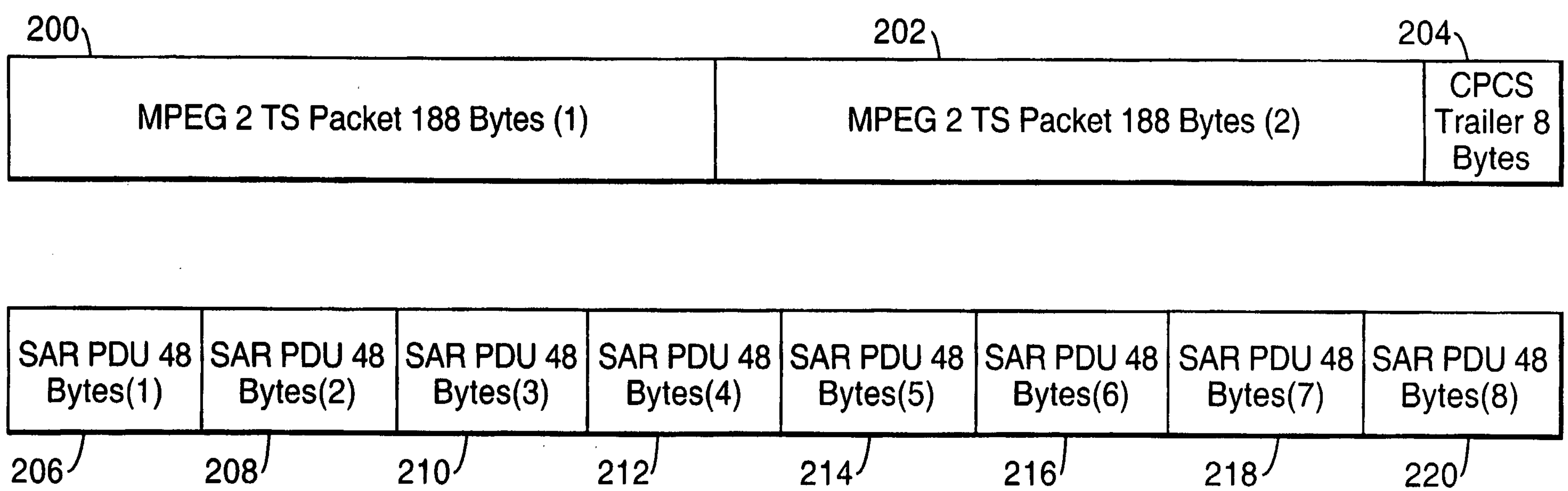
Fig.3.

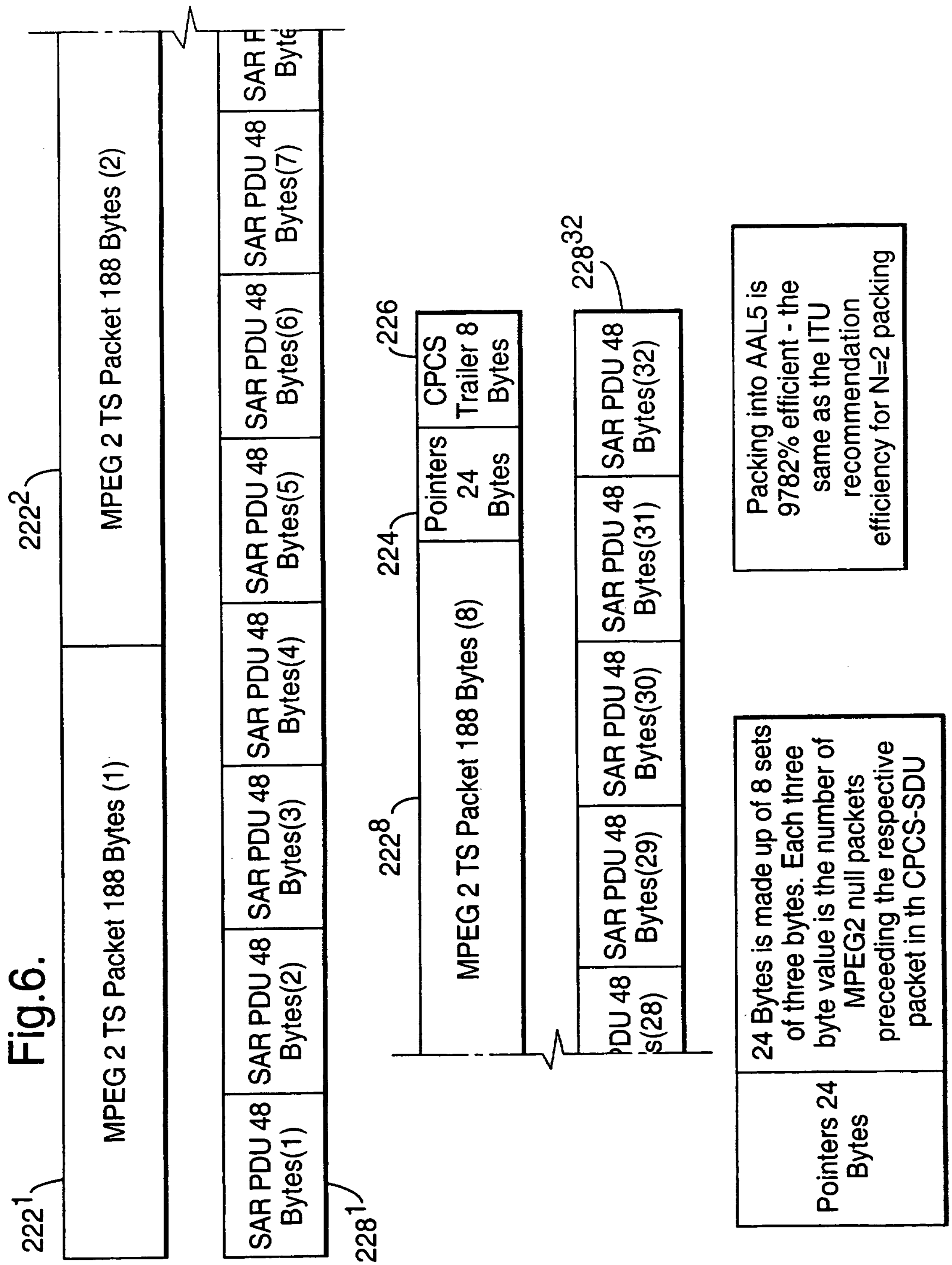


Rx
SAR PDUs
120
122
CPCS Buffer + Pointer Extraction
Pointer Data
124
MPEG Packets
126
Select
129
Null Generator
128
132
Jittered VBR
Multiplexer
134
138
Jittered CBR
CBR Clock Recovery
140
142
CBR-VBR Conversion
VBR
146
144 CBR Transport Stream

Fig.4.

Fig.5.


200
202
204
MPEG 2 TS Packet 188 Bytes (1)
MPEG 2 TS Packet 188 Bytes (2)
CPCS Trailer 8 Bytes
SAR PDU 48 Bytes(1)
SAR PDU 48 Bytes(2)
SAR PDU 48 Bytes(3)
SAR PDU 48 Bytes(4)
SAR PDU 48 Bytes(5)
SAR PDU 48 Bytes(6)
SAR PDU 48 Bytes(7)
SAR PDU 48 Bytes(8)
206
208
210
212
214
216
218
220



222¹
222²
MPEG 2 TS Packet 188 Bytes (1)
MPEG 2 TS Packet 188 Bytes (2)
SAR PDU 48 Bytes(1)
SAR PDU 48 Bytes(2)
SAR PDU 48 Bytes(3)
SAR PDU 48 Bytes(4)
SAR PDU 48 Bytes(5)
SAR PDU 48 Bytes(6)
SAR PDU 48 Bytes(7)
SAR P Byte
228¹
222⁸
224
226
MPEG 2 TS Packet 188 Bytes (8)
Pointers 24 Bytes
CPCS Trailer 8 Bytes
228³²
PDU 48 s(28)
SAR PDU 48 Bytes(29)
SAR PDU 48 Bytes(30)
SAR PDU 48 Bytes(31)
SAR PDU 48 Bytes(32)
Pointers 24 Bytes
24 Bytes is made up of 8 sets of three bytes. Each three byte value is the number of MPEG2 null packets preceding the respective packet in th CPCS-SDU
Packing into AAL5 is 9782% efficient - the same as the ITU recommendation efficiency for N=2 packing

Fig.6.

Improvements in or Relating to Statistical Multiplexing

The present invention relates to improvements in Statistical Multiplexing, particularly in respect of Statistical Multiplexing in variable bitrate (VBR) networks.

In known MPEG 2 Statistical Multiplexing systems a plurality of encoders are linked together in a group, each encoder encoding an individual channel. Based on "Quality" requirements the outputs from the individual encoders are varied and then multiplexed together to form a combined constant bitrate (CBR) group output. This generally works well. However, there are times when problems arise as a result of coherence. In other words there are times when all channels need a low bit rate and times when they all need a high bitrate. With respect to the low bitrate case, this is not a major problem as there is no need to compromise the quality of the individual channels. However, it is necessary to add some additional data or null packets to re-attain the constant bitrate of the group or to over-code the data using more bits than are necessary. This clearly has both potential advantages and disadvantages. With respect to the high bitrate case, there are much greater difficulties. As the group output must be at the CBR, if all channels require a high bitrate some will not be allocated sufficient bitrate and consequential reduction of quality will occur. In digital television this can have catastrophic effects on the viewing quality of the ultimate picture and indeed whether or not it is viewable at all.

There are clearly a number of problems associated with the above approach. One possible solution to some of the problems is to attempt to use a VBR network such as Asynchronous Transfer Mode (ATM). This takes advantage of ATM VBR services which are cheaper per mean Mbits/s compared to the known continuous bitrate schemes and enhances Statistical Multiplexing technology to improve the quality of picture coding during coherent coding data peaks within the group.

ATM allows several types of transmission options, often referred to as traffic contracts. For a CBR contract the CBR is simply defined by a required bitrate for the service. For a VBR contract the VBR is defined by a mean bitrate, a peak bitrate and a maximum burst duration at the peak bitrate. Given that VBR coding is desirable in the compression encoders and it is a service that ATM is well specified to provide then it would be good to match the two. Further details of the traffic contracts will be discussed later.

It is not straightforward to match VBR coding and ATM in this way. An additional problem arises since MPEG 2 Transport Stream (TS) must be a CBR between any two Program Clock References (PCRs) on the same Program Identifier (PID). Thus, if a VBR is required changes in the bitrate can only be made on a PCR PID boundary. In a single MPEG 2 TS there are usually more than one PCR PID flows, then since the two PCRs may not occupy the same packet location in the stream any bitrate change point will be between one or more PCRs and therefore violate the MPEG 2 standard. The result is that virtually all Transport streams must be CBR.

The present invention provides a solution to the above mentioned problems and further provides a VBR implementation for Statistical Multiplexing using an ATM network which does not contravene the requirements of the MPEG 2 Standard.

According to one aspect of the present invention, there is provided a statistical multiplexing method for combining one or more digital signals into a data stream and transmitting said data stream as a variable bitrate data stream. The method comprising the steps of: producing an artificial constant bitrate data stream from a combination of the or each digital signal and null material; and removing the null material from the constant bitrate data stream to produce the variable bitrate data stream.

This has the advantage that a VBR implementation for Statistical Multiplexing is provided using an ATM network, which implementation does not contravene the requirements of the MPEG 2 Standard. Since the transmission can occur at a VBR the bandwidth needed for transmission can be significantly reduced when compared to the CBR scheme. This has consequential cost savings for transmissions of specific numbers of signals.

According to a second aspect of the present invention, there is provided a Statistical Multiplexer for combining one or more digital signals into a data stream and transmitting said data stream as a variable bitrate data stream. The apparatus comprising: an artificial constant bitrate data stream generator

for generating an artificial constant bitrate data stream from a combination of the or each digital signal and null material; and a converter for removing the null material from the constant bitrate data stream to produce the variable bitrate data stream.

According to a third aspect of the present invention, there is provided a scheme for transmitting and receiving information over a variable bitrate network. The scheme comprising a statistical multiplexer for statistically multiplexing one or more digital signals into a data stream; a transmitter for transmitting the data stream over a variable bitrate network; a receiver for receiving the transmitted data stream; and a demultiplexer for converting the data stream into one or more digital signal.

Reference will now be made by way of example, to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a VBR transmission scheme according to one aspect of the present invention;

Figure 2 is a block diagram of one embodiment of an ATM Multiplexer shown in Figure 1;

Figure 3 is a block diagram of a Null Removal and Pointer Insertion block of the ATM Multiplexer in Figure 2;

Figure 4 is a block diagram of the receiver circuitry necessary to decode the output from the Figure 1 Statistical Multiplexer.

Figure 5 is a packet diagram of one mode of operation of ATM according to current use; and

Figure 6 is a packet diagram showing the proposed operation in accordance with the present invention.

Referring to Figure 1 a VBR transmission scheme 10 is shown. The VBR transmission scheme include a Statistical Multiplexer (not shown per se), which in turn includes a plurality of encoders 12 (12' 12" to 12^n). The encoders are connected to an ATM Multiplexer 14 both directly and via an Ethernet connection 16. The Ethernet carries bitrate instructions from the Statistical Multiplexer to the encoders and Quality requirements from the Statistical Multiplexer. The ATM Multiplexer will be described in more detail with respect to Figure 2 and Figure 3. The output 19 produced by the ATM Multiplexer is then transmitted via an ATM network 20.

At the receiver end of the transmission scheme the received signal 21 is passed through an ATM Demultiplexer 22, which reverses the effect of the multiplexer 14. The demultiplexed signal is then passed to a decoder 24 or to one or more COFDM modulators 26 and 28 for onward transmission. Obviously other options are available at this stage depending on the system requirements.

Referring now to Figure 2 one embodiment of the ATM Multiplexer 14 is shown. Packets of encoded data 40 are produced by the encoders of Figure 1 and passed to a Statistical Multiplexer Packet Buffer 42. The Buffer 42 produces a VBR output 44 and when appropriate an empty output 46. The VBR output 44 is passed to a multiplexer 48 and is combined with Null

Transport Stream Packets 50 to produce a CBR output 52. The empty output 46 from the Buffer 44 is passed to a Statistical Multiplexer Peak Packet Rate Heartbeat 54. This is used to control the number of Null Packets 50 that are combined with the VBR output to produce the CBR output 52 and to control their output at a regular beat. More packets are inserted when the VBR output is low and vice versa. The CBR output 52 is then processed to remove the null packets and insert a pointer 56 and to produce the ATM layers 58. This processing then produces an ATM output 60. The null removal and pointer insertion block also generates the ATM cell data rate 62, which co-operates with the Traffic Contract Manager 64. The Traffic Contract Manager 64 controls the bitrate required by the ATM output over the ATM network (Figure 1) and feeds back available bitrate levels to the Statistical Multiplexer via Statistical Multiplexer Instructions 66.

Figure 3 shows the Null Removal and Pointer Insertion Block 56 of Figure 2 in more detail. Packets 80 from the CBR output (Figure 2) are passed to a Packet Buffer 86 and a Null Detector 82. The Null Detector passes two command messages 84 and 88 to the Buffer 86 and a Counter 90 respectively. The message 84 to the Packet Buffer is a read enablement message, which allows non-null packets to be read. The message 88 is a count enablement message, which updates the counter. The output 92 from the counter is passed to a Buffer queue pointer 94. The output from the Packet Buffer and the Buffer Queue Pointer is passed to a Common Part Convergence Sub-layer (CPCS) Buffer 98. In addition the Buffer 98 receives an input from a CPCS Trailer Generator 96. The CPCS Buffer works to

produce the ATM output cells 104 with a cell heartbeat generator 100 and a controller 102. The controller 102 is a Segment and Reassembly (SAR) Protocol Delivery Unit (PDU) queue and traffic controller which puts together the ATM cells in the correct format. The cell heartbeat generator ensures that the packets or cells are output at regular intervals or "heartbeats" so as not to violate the Traffic Contract. The SAR PDU cells form the payload carrying the encoded and multiplexed video audio and/or data signals.

At the receiver end as shown in Figure 1 and Figure 4 the input cells 21 or 120 undergo a reverse process to that at the transmitter. This will be described in more detail with reference to Figure 4. The SAR PDU cells 120 are passed to a CPCS Buffer and pointer extraction block 122 which separates the payload from the control signals for each cell. The exact details of the transmitted and received signals are described with reference to Figures 5 and 6 below. The Buffer 122 generates pointer data 124, MPEG packets 126 and as required causes Null packets 132 to be generated. The Null packets are produced by a Null Generator 128 and are selected via a selector command 129. The MPEG packets form a jittered VBR. The Jitter is a time variation in the arrival of cells (or packets) caused by the different delays each cell experiences as it passes through the ATM Network. The MPEG packets 124, the null packets 132 and the pointer data 124 are all passed to a multiplexer 134. This reproduces a jittered CBR Transport Stream 138, which is passed through a CBR Clock Recovery Block 140 and then a CBR to VBR converter 142 for local decoding. Alternatively the clock-

recovered signal may be passed as 144 onto forward CBR transmission media 146.

The ATM Traffic Contract Manager 64 controls the Traffic Contract of the ATM output. The Traffic Contract is defined by the Peak Cell Rate (PKCR), the Sustained Cell Rate (SCR) (also known as the mean rate of transmission) and the Maximum Peak Duration (MPD) (in other words the longest period of time for which the PKCR may be maintained). This can also be expressed as follows:

$$\text{as MPD} \rightarrow \infty \text{ then VBR} = \text{CBR @ PKCR}$$

The VBR output described above is combined with sufficient Null Packets (according to MPEG2) to produce a CBR output 52 at approximately the Peak Cell Rate. In actual fact the bitrate is slightly less to account for insertion of a pointer. This means that whatever the bitrate of the sum of the encoders in the Statistical Multiplexer Group the output rate is a CBR at just less than the PKCR made up of a varying quantity of Null and valid Statistical Multiplexer data.

In adapting the MPEG2 TS or CBR output 52 to the ATM network each MPEG2 TS packet is checked to see if it is a Null or not. If it is a Null then it is excluded from the ATM output 60. The counter 90 retains the number of Null packets since the last packet that was not a Null. On the arrival of the next non-Null packet the counter value is written into a register and the counter reset to count the number of Null packets following this valid packet. This

register is a pointer that indicates the number of Null packets between the two valid data packets. This process is repeated a number of times. A good match to current standards is to repeat this process 8 times to have a Buffer now containing eight MPEG2 TS packets and eight pointer values. These may then be combined with ATM Adaptation Layer (AAL) formatting to form an AAL5 payload of 1536 bytes. These are divided according to ATM standards into thirty two 48 byte blocks for transmission. By not transmitting the Null packets but inserting pointers instead the generation of the 1536 byte block becomes a variable rate depending on the number of Null packets in the stream. The equipment will monitor the rate at which these cells are generated (now and in the past) and compare that rate against the traffic contract and send instructions back to Statistical Multiplex controller about allowable video coding rates.

The eight MPEG2 TS packets and eight 24 bit pointers combined into one block with an mandatory 8 byte trailer has the same overhead percentage as the current standard of two MPEG2 TS packets and 8 byte trailer (97.82 percent). See below for further details.

At the receiver end the Buffer 122 synchronises using defined ATM techniques, and stores 8 packet/8 pointer blocks and uses the pointers to re-insert the Null packets. This regenerates a CBR MPEG2 TS which may be clock recovered (ATM introduces massive cell delay variation across the network that must be removed for MPEG data to be decoded and displayed

correctly). The regenerated CBR TS may now be re-transmitted over a satellite/terrestrial or cable network or decoded immediately.

Referring now to Figures 5 and 6 two schemes of ATM packetisation are shown. Figure 5 shows the commonly used packet format where two MPEG2 TS 188 byte packets 200 and 202 are to be transmitted with an 8 byte CPCS Trailer 204. The packets 200 and 202 and the trailer 204 are converted into eight SAR PDU 48 byte packets 206 to 220. Figure 6 shows the approach adopted in the present invention. In this case eight MPEG2 TS 188 byte packets 222^1 to 222^8, a 24byte pointer 224 and a CPCS 8 byte trailer 226 are to be transmitted. The pointers give indications of null packets removed by the coding process and are needed to reconstruct the CBR resultant output at the receiver. The information to be transmitted is converted into 32 SAR PDU 48 byte packets 228^1 to 222^{32}.

The invention is not limited to use with video signals but can be used for all types of digital signals where Statistical Multiplexing is relevant. It will be further appreciated that the references to ATM are not limiting and that the invention will work equally well with other types of VBR Network.

Instead of actually generating a CBR data stream by introducing Null Information it would also be possible to produce a virtual CBR data stream. One way in which such a virtual stream could be produced is to identify where a Null would have been inserted and instead insert a Null Counter. Either of

these would reduce the processing of the signal during later stages of the process.

This invention has been illustrated with multiple encoders producing multiple data or transport streams. It would also apply to a situation where there is only one encoder and a single transport stream. In the multiple encoder example the ATM Multiplexer includes the function of an ATM Concentrator. In the single encoder example the ATM Multiplexer does not include the function of the ATM Concentrator.

Claims

1. A statistical multiplexing method for combining one or more digital signals into a data stream and transmitting said data stream as a variable bitrate data stream, comprising the steps of:

   producing an artificial constant bitrate data stream from a combination of the or each digital signal and null material; and

   removing the null material from the constant bitrate data stream to produce the variable bitrate data stream.

2. The method of claim 1, wherein the removing step comprises coding the null material.

3. The method of claim 1 or claim 2, wherein the step of producing the artificial constant bitrate data steam comprises multiplexing the or each digital signal and null material to form the artificial constant bitrate data stream.

4. The method of claim 3, further comprising controlling the amount of null material multiplexed with the or each digital signal in dependence on the bitrate of the or each digital signal.

5. The method of any preceding claim, further comprising transmitting the variable bitrate data stream across a variable bitrate network.

6. The method of claim 5, further comprising providing the variable bitrate network as an Asynchronous Transfer Mode (ATM) network.

7. The method of any preceding claim, further comprising generating a plurality of digital signals from encoders in a Statistical Multiplexing Group.

8. A Statistical Multiplexer for combining one or more digital signals into a data stream and transmitting said data stream as a variable bitrate data stream, comprising:

   an artificial constant bitrate data stream generator for generating an artificial constant bitrate data stream from a combination of the or each digital signal and null material; and

   a converter for removing the null material from the constant bitrate data stream to produce the variable bitrate data stream.

9. The apparatus of claim 8, further comprising a coder for encoding the null material.

10. The apparatus of claim 8 or claim 9, wherein the artificial constant bitrate data steam generator comprises a multiplexer.

11. The apparatus of any of claims 8 to 10, wherein the amount of null material multiplexed with the or each digital signal is dependant on the bitrate of the or each digital signal.

12. The apparatus of any of claims 8 to 11, further comprising a transmitter for transmitting the variable bitrate data stream across a variable bitrate network.

13. The apparatus of claim 12, wherein the variable bitrate network is an Asynchronous Transfer Mode (ATM) network.

14. The apparatus of any of claims 8 to 13, wherein the one or more digital signals comprises a plurality of digital signals from encoders in a Statistical Multiplexing Group.

15. A statistical demultiplexing method for demultiplexing a variable bitrate data stream into one or more digital signals, said variable bitrate data

stream having been transmitted over a variable bitrate network, comprising the steps of:

adding null material to the variable bitrate data stream to form an artificial constant bitrate data stream: and

demultiplexing the artificial constant bitrate data stream to generate one or more digital signal and null material.

16. A statistical demultiplexer for demultiplexing a variable bitrate data stream into one or more digital signals, said variable bitrate data stream having been transmitted over a variable bitrate network, comprising :

an adder for adding null material to the variable bitrate data stream to form an artificial constant bitrate data stream; and

a demultiplexer for demultiplexing the artificial constant bitrate data stream to generate one or more digital signal and null material.

17. A method of transmitting information over a variable bitrate network comprising:

statistically multiplexing one or more digital signals into a data stream; and

transmitting the data stream over a variable bitrate network.

18. A transmitter for transmitting information over a variable bitrate network comprising:

a statistical multiplexer for statistically multiplexing one or more digital signals into a data stream; and

a transmitter for transmitting the data stream over a variable bitrate network.

19. A scheme for transmitting and receiving information over a variable bitrate network comprising

a statistical multiplexer for statistically multiplexing one or more digital signals into a data stream;

a transmitter for transmitting the data stream over a variable bitrate network;

a receiver for receiving the transmitted data stream; and

a demultiplexer for converting the data stream into one or more digital signal.

The Patent Office

INVESTOR IN PEOPLE

Application No:	GB 9926899.7	**Examiner:**	Richard Howe
Claims searched:	1 - 19	**Date of search:**	10 January 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H4M (MN) ; H4K (KTK)

Int Cl (Ed.7): H04J (3/16)

Other: Online : wpi ; epodoc ; japio

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	WO 98/43376 A1 (Scientific-Atlanta) - see abstract	17,18,19
X	WO 98/34362 A1 (Kohl) - see abstract	1,3,5,8,12,15,16,17, 18 and 19

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		